

## AMENDMENTS TO THE CLAIMS

Claim 1 (**Currently Amended**)      An image processing apparatus comprising:

a contrast improvement unit operable to perform a contrast improvement process on an input image by comparing an object pixel of the input image with pixels that belong to surrounding areas of the object pixel, the contrast improvement unit comprising a correction data calculation unit operable to find a contrast improvement amount for a pixel in the input image, an extraction unit operable to extract an effective range from distribution of the contrast improvement amount, and a pixel value conversion unit operable to convert a contrast improvement amount of the object pixel to a value of a corresponding pixel in the enhanced image according to the extracted range;

an image combination unit operable to combine an enhanced image obtained by the contrast improvement unit and the input image; and

an image output unit operable to output the image after combination,  
wherein the pixel value conversion unit comprises a standard intensity calculation unit operable to calculate a standard intensity value that indicates contrast intensity of the input image, a conversion curve estimation unit operable to estimate a conversion curve for converting the contrast improvement amount to a value in the enhanced image based on the standard intensity value, and a pixel value estimation unit operable to use the conversion curve to convert the contrast improvement amount to a value in the enhanced image, and

wherein the conversion curve estimation unit comprises an initial candidate setting unit operable to set an initial population of search vectors that indicate conversion curves, a pixel value conversion candidate calculation unit operable to find a conversion value in a candidate for an enhanced image from the contrast improvement amount using a conversion curve candidate corresponding to each search vector, an evaluation value calculation unit operable to use the standard intensity value and the conversion value to calculate an evaluation value for evaluating the candidates of each conversion curve, a fitness calculation unit operable to calculate fitness of a candidate of each conversion curve based on the evaluation value, a recombination operation unit operable to perform recombination operation on a search vector selected based on the fitness

of the candidates of each conversion curve and generate a next generation population, and an estimation end judgment unit operable to determine whether or not estimation of the conversion curve ends at a current generation.

#### Claims 2-6 (Canceled)

**Claim 7 (Currently Amended)**      An image processing apparatus comprising:  
a contrast improvement unit operable to perform a contrast improvement process on an input image by comparing an object pixel of the input image with pixels that belong to surrounding areas of the object pixel.~~The image processing apparatus of claim 1 wherein~~  
~~the contrast improvement unit comprises:~~ comprising a signal conversion unit operable to convert a value of pixel in the input image to a plurality of signals that include a signal that is an object of contrast ~~improvement;~~ improvement, an object correction data calculation unit operable to find a contrast improvement amount of the object pixel for an object signal obtained from the signal conversion ~~unit;~~ unit, an extraction unit operable to extract an effective range from distribution of the contrast improvement amount for the object ~~signal;~~ signal, an object signal conversion unit operable to convert the contrast improvement amount for the object signal to a value of the object signal in the enhanced ~~image;~~ image, and a signal inverse conversion unit operable to find a value of pixel in the enhanced image based on the object signal of the enhanced image and signals other than the object signal obtained by the signal conversion unit;  
an image combination unit operable to combine an enhanced image obtained by the contrast improvement unit and the input image; and  
an image output unit operable to output the image after combination,  
wherein the object signal conversion unit comprises a standard intensity calculation unit operable to calculate a standard intensity value that indicates contrast intensity of the input image for the object signal obtained by the signal conversion unit, an object signal conversion curve estimation unit operable to estimate a conversion curve for converting the contrast improvement amount for the object signal to the value in the enhanced image based on the standard intensity

value, and an object signal estimation unit operable to use the estimated conversion curve to convert the contrast improvement amount for the object signal to the value in the enhanced image, and

wherein the object signal conversion curve estimation unit comprises an initial candidate setting unit operable to set an initial population of search vectors that indicate conversion curves, an object signal conversion candidate calculation unit operable to find a conversion value for the object signal in a candidate for an enhanced image from the contrast improvement amount for the object signal using a conversion curve candidate corresponding to each search vector, an evaluation value calculation unit operable to use the standard intensity value and the conversion value to calculate an evaluation value for evaluating the candidates of each conversion curve, a fitness calculation unit operable to calculate fitness of a candidate of each conversion curve based on the evaluation value, a recombination operation unit operable to perform recombination operation on a search vector selected based on the fitness of the candidates of each conversion curve and generate a next generation population, and an estimation end judgment unit operable to determine whether or not estimation of the conversion curve ends at current generation.

#### Claims 8-16 (Canceled)

**Claim 17 (Currently Amended)** An image processing apparatus comprising:

a contrast improvement unit operable to perform a contrast improvement process on an input image by comparing an object pixel in the input image with pixels that belong to surrounding areas of the object pixel;

a density correction unit operable to correct density distribution of an enhanced image obtained by the contrast improvement unit according to density distribution of the input image;

an image combination unit operable to combine a corrected image obtained by the density correction unit and the input image; and

an image output unit operable to output an image after combination,

wherein the contrast improvement unit comprises a comparison pixel setting unit

operable to set positions in a vertical direction of pixels to be used in the comparison from among pixels in the area surrounding the object pixel, a vertical direction addition unit operable to add weighting in the vertical direction to the density of the comparison pixels obtained by the comparison pixel setting unit, a simple surrounding average unit operable to calculate comparison density for the object pixel from a value at each horizontal pixel position in the surrounding area obtained by the vertical direction addition unit, an improvement amount calculation unit operable to find a contrast improvement amount from the comparison density and density of the object pixel, a conversion standard value calculation unit operable to find a conversion standard value for converting the contrast improvement amount to a value of pixel in the enhanced image, and a pixel value conversion unit operable to convert the contrast improvement amount to a value of pixel in the enhanced image based on the conversion standard value.

#### Claims 18-27 (Canceled)

Claim 28 (Currently Amended)     An image processing apparatus comprising:

- a pre-processing unit operable to perform pre-processing on an input image;
  - a contrast improvement unit operable to perform a contrast improvement process on the pre-processed image by comparing an object pixel of the pre-processed image with pixels that belong to surrounding areas of the object pixel;
  - an image combination unit operable to combine an enhanced image obtained by the contrast improvement unit and the input image;
  - a post-processing unit operable to perform post-processing on an image after combination; and
  - an image output unit operable to output the post-processed image,
- wherein the contrast improvement unit comprises a comparison pixel setting unit operable to set positions in a vertical direction of pixels to be used in the comparison from among pixels in the area surrounding the object pixel, a vertical direction addition unit operable

to add weighting in the vertical direction to the density of the comparison pixels obtained by the comparison pixel setting unit, a simple surrounding average unit operable to calculate comparison density for the object pixel from a value at each horizontal pixel position in the surrounding area obtained by the vertical direction addition unit, an improvement amount calculation unit operable to find a contrast improvement amount from the comparison density and density of the object pixel, a conversion standard value calculation unit operable to find a conversion standard value for converting the contrast improvement amount to a value of pixel in the enhanced image, and a pixel value conversion unit operable to convert the contrast improvement amount to a value of pixel in the enhanced image based on the conversion standard value.

Claims 29-33 (Canceled)

Claim 34 (Currently Amended)     ~~The image processing apparatus of claim 28~~ An image processing apparatus comprising:

a pre-processing unit operable to perform pre-processing on an input image;

a contrast improvement unit operable to perform a contrast improvement process on the pre-processed image by comparing an object pixel of the pre-processed image with pixels that belong to surrounding areas of the object pixel;

an image combination unit operable to combine an enhanced image obtained by the contrast improvement unit and the input image;

a post-processing unit operable to perform post-processing on an image after combination; and

an image output unit operable to output the post-processed image, wherein

wherein the contrast improvement unit comprises: ~~comprises~~ a comparison pixel setting unit operable to set positions in a vertical direction and positions in a horizontal direction of pixels to be used in the comparison from among pixels in the area surrounding the object pixel; a removal vertical direction addition unit operable to add weighting to the vertical

direction of the density of the comparison pixels obtained by the comparison pixel setting ~~unit~~; unit, a simple surrounding average unit operable to calculate comparison density for the object pixel based on an addition value obtained by the removal vertical direction addition ~~unit~~; unit, an improvement amount calculation unit operable to find a contrast improvement amount from the comparison density and density of the object ~~pixel~~; pixel, a conversion standard value calculation unit operable to find a conversion standard value for converting the contrast improvement amount to a value of pixel in the enhanced ~~image~~; image, and a pixel value conversion unit operable to convert the contrast improvement amount to a value of pixel in the enhanced image based on the conversion standard value.

#### Claims 35-37 (Canceled)

Claim 38 (Currently Amended) An image processing method comprising:

a contrast improvement step of performing a contrast improvement process on an input image by comparing an object pixel of the input image with pixels that belong to surrounding areas of the object pixel, the contrast improvement step comprising a step of finding a contrast improvement amount for a pixel in the input image, a step of extracting an effective range from distribution of the contrast improvement amount, and a pixel value conversion step of converting the contrast improvement amount of the object pixel to a value of corresponding pixel in the enhanced image according to the extracted range;

an image combination step of combining an enhanced image obtained from the contrast improvement unit and the input image; and

a step of outputting an image after combination,

wherein the pixel value conversion step comprises a step of calculating the standard intensity value that indicates contrast intensity of the input image, a conversion curve estimation step of estimating a conversion curve for converting the contrast improvement amount to a value in the enhanced image, and a step of using the conversion curve to convert the contrast improvement amount to a value in the enhanced image, and

wherein the conversion curve estimation step comprises a step of setting an initial population of search vectors that indicate conversion curves, a step of finding a conversion value in a candidate for an enhanced image from the contrast improvement amount using a conversion curve candidate corresponding to each search vector, a step of using the standard intensity value and the conversion value to calculate an evaluation value for evaluating the candidates of each conversion curve; a step of calculating fitness of a candidate of each conversion curve based on the evaluation value, a step of performing recombination operation on a search vector selected based on the fitness of the candidates of each conversion curve and generating a next generation population, and a step of determining whether or not estimation of the conversion curve ends at current generation.

Claims 39-43 (Canceled)

Claim 44 (Currently Amended)     ~~The image processing method of claim 38~~ An image processing method comprising:

a contrast improvement step of performing a contrast improvement process on an input image by comparing an object pixel of the input image with pixels that belong to surrounding areas of the object pixel;

an image combination step of combining an enhanced image obtained from the contrast improvement unit and the input image; and

a step of outputting an image after combination ~~wherein~~

wherein the contrast improvement step comprises: ~~comprises~~ a signal conversion step of converting a value of pixel in the input image to a plurality of signals that include the signal that is an object of contrast ~~improvement~~; improvement, a step of finding a contrast improvement amount of the object pixel for an object signal obtained from the signal conversion ~~step~~; step, a step of extracting an effective range from distribution of the contrast improvement amount for the object ~~signal~~; signal, an object signal conversion step of converting the contrast improvement amount for the object signal to a value of the object signal in the enhanced ~~image~~; image, and a

step of finding a value of pixel in the enhanced image based on the object signal of the enhanced image and signals other than the object signal obtained by the signal conversion step, and

wherein the object signal conversion step comprises a step of calculating a standard intensity value that indicates contrast intensity of the input image for the object signal obtained by the signal conversion step, an object signal conversion curve estimation step of estimating a conversion curve for converting the contrast improvement amount for the object signal to a value in the enhanced image, and a step of using the estimated conversion curve to convert the contrast improvement amount for the object signal to a value in the enhanced image, and

wherein the object signal conversion curve estimation step comprises a step of setting an initial population of search vectors that indicate conversion curves, a step of finding conversion value for the object signal in a candidate for an enhanced image from the contrast improvement amount for the object signal using a conversion curve candidate corresponding to each search vector, a step of using the standard intensity value and the conversion value to calculate an evaluation value for evaluating the candidates of each conversion curve, a step of calculating fitness of the candidates of each conversion curve based on the evaluation value, a step of performing recombination operation on a search vector selected based on the fitness of the candidates of each conversion curve and generating a next generation population, and a step of determining whether or not estimation of the conversion curve ends at current generation.

Claim 45-63 (**Canceled**)

Claim 64 (**Currently Amended**)     An image processing method comprising:

- a pre-processing step of performing pre-processing on an input image;
- a contrast improvement step of performing a contrast improvement process on the pre-processed image by comparing an object pixel of the pre-processed image with pixels that belong to surrounding areas of the object pixel;
- a step of combining an enhanced image obtained by the contrast improvement step and the input image;

a post-processing step of performing post-processing on an image after combination; and  
 a step of outputting the post-processed image, wherein  
the contrast improvement step comprises a step of setting positions in a vertical direction  
of pixels to be used in the comparison from among pixels in the area surrounding the object  
pixel, a vertical direction addition step of adding weighting in the vertical direction to the density  
of the comparison pixels obtained by the setting a step of calculating comparison density for the  
object pixel from a value at each horizontal pixel position in the surrounding area obtained by the  
vertical direction addition step, a step of finding a contrast improvement amount from the  
comparison density and density of the object pixel, a step of finding a conversion standard value  
for converting the contrast improvement amount to a value of pixel in the enhanced image, and a  
step of converting the contrast improvement amount to a value of the pixel in the enhanced  
image based on the conversion standard value.

#### Claims 65-69 (Canceled)

Claim 70 (Currently Amended)    ~~The image processing method of claim 64~~ An image  
processing method comprising:

a pre-processing step of performing pre-processing on an input image;  
a contrast improvement step of performing a contrast improvement process on the pre-  
processed image by comparing an object pixel of the pre-processed image with pixels that belong  
to surrounding areas of the object pixel;  
a step of combining an enhanced image obtained by the contrast improvement step and  
the input image;  
a post-processing step of performing post-processing on an image after combination; and  
a step of outputting the post-processed image, wherein  
wherein the contrast improvement step comprises: comprises a step of setting positions in  
a vertical direction and positions in a horizontal direction of pixels to be used in the comparison  
from among pixels in the area surrounding the object pixel; pixel, a removal vertical direction

addition step of adding weighting to the vertical direction of the density of the comparison pixels obtained by the ~~setting;~~ setting, a step of calculating comparison density for the object pixel based on an addition value obtained by the removal vertical direction addition ~~step;~~ step, a step of finding a contrast improvement amount from the comparison density and density of the object ~~pixel;~~ pixel, a step of finding a conversion standard value for converting the contrast improvement amount to a value of pixel in the enhanced ~~image;~~ image, and a step of converting the contrast improvement amount to a value of pixel in the enhanced image based on the conversion standard value.

#### Claims 71-79 (Canceled)

Claim 80 (Currently Amended)     ~~The image processing apparatus of claim 17~~ An image processing apparatus comprising:

a contrast improvement unit operable to perform a contrast improvement process on an input image by comparing an object pixel in the input image with pixels that belong to surrounding areas of the object pixel;

a density correction unit operable to correct density distribution of an enhanced image obtained by the contrast improvement unit according to density distribution of the input image;

an image combination unit operable to combine a corrected image obtained by the density correction unit and the input image; and

an image output unit operable to output an image after combination, ~~wherein~~  
wherein the contrast improvement unit comprises; ~~comprises~~ a comparison pixel setting unit operable to set positions in a vertical direction and positions in a horizontal direction of pixels to be used in the comparison from among pixels in the area surrounding the object ~~pixel;~~ pixel, a removal vertical direction addition unit operable to add weighting to the vertical direction of the density of the comparison pixels obtained by the comparison pixel setting ~~unit;~~ unit, a simple surrounding average unit operable to calculate comparison density for the object pixel based on an addition value obtained by the removal vertical direction addition ~~unit;~~ unit, an

improvement amount calculation unit operable to find a contrast improvement amount from the comparison density and density of the object ~~pixel~~, pixel, a conversion standard value calculation unit operable to find a conversion standard value for converting the contrast improvement amount to a value of pixel in the enhanced ~~image~~, image, and a pixel value conversion unit operable to convert the contrast improvement amount to a value of pixel in the enhanced image based on the conversion standard value.

Claims 81-87 (**Canceled**)